

THE X-43A (HYPER-X) FLIES INTO THE RECORD BOOKS

Summary

The goal of the Hyper-X research program, conducted jointly by the NASA Dryden Flight Research Center and the NASA Langley Research Center, was to demonstrate and validate the technology, experimental techniques, and computation methods and tools for design and performance predictions of a hypersonic aircraft with an airframe-integrated, scramjet propulsion system. Three X-43A airframe-integrated, scramjet research vehicles were designed and fabricated to achieve that goal by flight test: two test flights at Mach 7 and one test flight at Mach 10. The first flight, conducted on June 2, 2001, experienced a launch vehicle failure and resulted in a 9-month mishap investigation. A two-year return-to-flight effort ensued and concluded when the second Mach 7 flight was successful on March 27, 2004. Just eight months later, on November 16, the X-43A successfully completed the third and final flight. These two flights were the first flight demonstrations, at Mach 7 and Mach 10 respectively, of an airframe-integrated, scramjet-powered, hypersonic vehicle.

Objective

The primary objective of the X-43A project was to demonstrate the performance of an airframe-integrated, scramjet-powered vehicle at selected test conditions. Data were acquired to verify scramjet, aerodynamics, and stability and control performance predictions as well as to perform flight correlation of the ground-based experimental data. In addition, data were acquired to verify the hypersonic vehicle structural integrity and system design.

Approach

The X-43A missions were designed such that the maximum amount of data could be obtained to demonstrate and validate the technology, design tools and techniques.

Mission Overview

Following release from the NASA B-52B (The Boeing Company, Chicago, Illinois) airplane, tail number 008, the Hyper-X Launch Vehicle (HXLV), a modified first stage Pegasus[®] (Orbital Sciences Corporation, Dulles, Virginia) rocket booster, launched the X-43A to the predetermined research test conditions (fig. 1). After separation from the HXLV and during the engine test phase, the X-43A engine ignited and operated for approximately 10 s. Following the Mach 7 engine operation, a parameter identification (PID) maneuver was performed. Subsequent to the engine sequence, the X-43A performed a recovery maneuver to begin the controlled predetermined descent trajectory. During the descent, PID, push-over-pull-up, and frequency sweep maneuvers were performed to assess aerodynamic characteristics and open-loop frequency response.



Figure 1. Hyper-X Launch Vehicle boost.

Mach 7 and Mach 10 Flight Results

For both the Mach 7 and Mach 10 missions, the HXLV maintained nominal attitude throughout the boost, closely followed the predicted trajectory, and delivered the X-43A to the desired separation conditions well within the specified tolerance. After issuing the “separate” command, the X-43A successfully separated from the HXLV and achieved stable flight. The adapter cameras looking at the aft end of the X-43A captured the separation event, as shown in figure 2. Following separation, the engine sequence began. During the powered flight of the Mach 7 mission, scramjet engine performance was within 3 percent of the preflight predictions and sufficient to overcome additional airframe drag and produce net positive thrust (fig. 3). The maximum powered Mach number achieved was 6.8. For the Mach 10 mission, the vehicle achieved a cruise condition with a maximum powered Mach number of 9.6. For both flights, the X-43A remained controlled from separation through the engine test and descent and successfully completed the descent maneuvers. All systems on both the launch vehicle and the X-43A performed well and extensive research quality data was acquired throughout the flight.

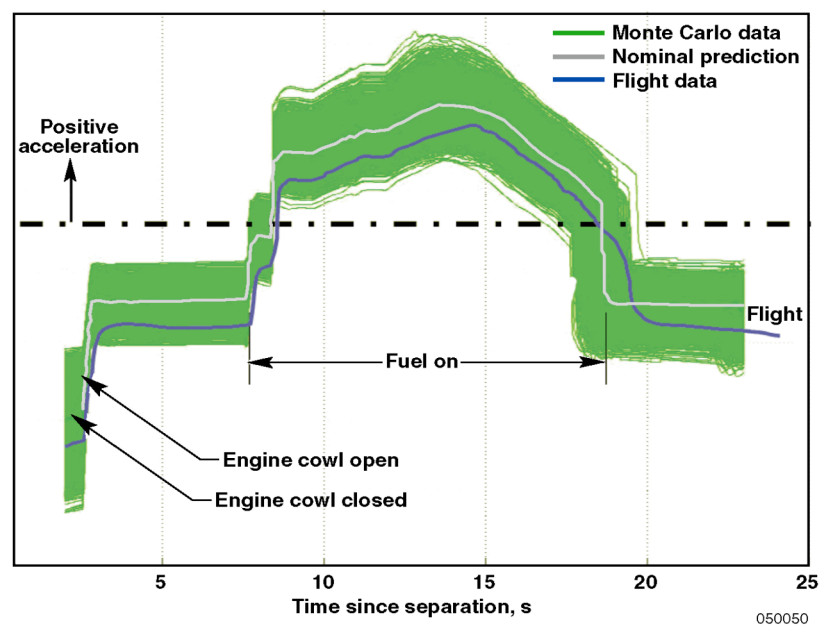
Status

Although the project concluded with the completion of the Mach 10 flight, the data continues to be analyzed.



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Figure 2. Adapter camera view of X-43A separation.



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Figure 3. Mach 7 axial acceleration profile during the engine test.

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